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ELISHA MITCHELL SCIENTIFIC SOCIETY

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NOTE ON IMAGINARY ROOTS OF A CUBIC.

BY WM. CAIN.

The expression,

$$y = f(x) = (x-c)(x-a+b\sqrt{-1})(x-a-b\sqrt{-1})$$
$$= (x-c)[(x-a)^2+b^2]$$

when placed equal to zero, is a cubic having one real root c and two imaginary roots $a+b\sqrt{-1}$ and $a-b\sqrt{-1}$.

Forming the first and second derivatives,

$$f'(x) = 3x^2 - 2(2a+c)x + (a^2+2ac+b^2),$$
$$f''(x) = 6x - 2(2a+c),$$

and placing them equal to zero, we note from the first, that the curve $y = f(x)$ has maximum and minimum ordinates at,

$$x' = \tfrac{1}{3}(2a+c-\sqrt{(a-c)^2-3b^2})$$
$$x'' = \tfrac{1}{3}(2a+c+\sqrt{(a-c)^2-3b^2})$$

and from the second, that there is a point of inflection at,

$$x_0 = \frac{2a+c}{3}$$

Since $f''(x)$ changes sign as it passes through this point. The curve is concave downwards to left of x_0, since then $f''(x)$ is negative and concave upwards to right of x_0 when $f''(x)$ is positive.

There are two cases.

(1) When $y = f(x)$ has horizontal tangents, which occurs when x' and x'' are real or $(a - c)^2$ *is greater than* $3b^2$ (fig. 1). It may be noted that x'' *is less than* a, since for $b = 0$ or

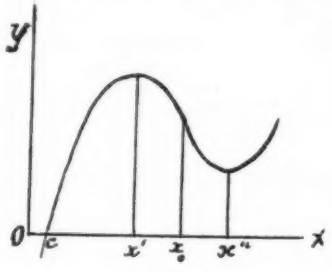


Fig. 1

two equal roots a, $y = f(x)$ is tangent to the x axis and $x'' = \frac{1}{3}(2a + c + a - c) = a$. Therefore when b is not zero, x'' *is less than* a from its value above. Hence the real part a of imaginary roots is always greater than x'' in case 1.

An interesting property of the curve is that,

$$x_0 = \tfrac{1}{3}(2a + c) = \tfrac{1}{2}(x' + x'')$$

or the abscissa of the point of inflection is a mean of the abscissas of the points where the tangents are horizontal.

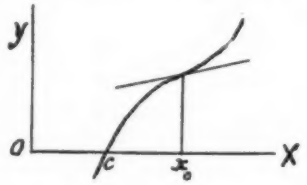


Fig. 2

(2) When x' and x'' are imaginary, the curve has no horizontal tangent. This case is illustrated by fig. 2. The curve, as shown above, is concave downwards to the left of the point

of infection and to the right of it, concave upwards. Hence it can only meet the axis of x once where $x = c$, the other two roots being imaginary.

A general test as to the character of the roots of any cubic may now be stated.

If in any $y = f(x)$, the roots of $f'(x) = 0 (x', x'')$ are *real* and $f(x')$, $f(x'')$ are of the same sign (fig. 1) two roots are imaginary; if of different signs, real. In the last case, the curve not only crosses the axis of a at $x = c$ but at two other points, whose abscissas corresponding to $f(x) = 0$ give the other two real roots.

If however x' and x'', the two roots of $f'(x) = 0$ are imaginary (fig. 2), it follows at once that two roots of $f(x) = 0$ are imaginary, since the curve after crossing the x axis at $x = c$ cannot cross it again, since there are no horizontal tangents and $y = f(x)$ continues to increase as x increases.

Example under case 1.

$$f(x) = x^3 - 7x^2 + 16x - 10 = 0$$
$$f'(x) = 3x^2 - 14x + 16 = 0 \text{ at } x' = 2, \; x'' = \tfrac{8}{3}$$

$f(2) = +2$, $f(\frac{8}{3}) = +\frac{50}{27}$, both having the plus sign, therefore there are two imaginary roots.

Observe here, as stated above, that $f''(x) = 6x - 14 = 0$ at $x_0 = \frac{7}{3} = \frac{1}{2}(x' + x'')$.

Example under case 2.

$$f(x) = x^3 - 5x^2 + 9x - 5 = 0.$$
$$f'(x) = 3x^2 - 10x + 9 = 0 \text{ at } x = \frac{5 \pm \sqrt{-2}}{3}.$$

These values being imaginary, there are no horizontal tangents; hence two of the roots are imaginary. The test in this case is very simple.

It will be observed that this method of ascertaining the existence or non-existence of imaginary roots does not involve the discriminant and is thus independent of usual tests. The graph of the curve is also more easily made when the maximum and minimum values of y and the inflection point have been found.

THE WOODY PLANTS OF CHAPEL HILL, N. C.

W. C. COKER.

Chapel Hill is situated in Orange County, N. C. at about latitude 79 and longitude 36. It is about 40 miles west of the Fall Line, and has an altitude of 500 feet.

The topography, the Geopraphical position, and the Geological formation of the Chapel Hill region all contribute towards the remarkable diversity of its plant forms. The soil is predominently Cecil Clay (of granitic orgin), but low areas of poorly drained soil known as Iredell Clay Loam (of volcanic origin) are found to the west of the town, and about two miles southward a stiff ridge of stratified rocks (Monroe Slates) runs east and west. A mile towards the east occurs the purple sandstone of the Triassic. Numerous streams both large and small have carved out a series of hills and ravines which offer every requirement of moisture, while on the Clay Loam are scattered here and there shallow ponds and boggy depressions.

According to Mr. C. Hart Merriam's arrangement of life zones, Chapel Hill is situated on the extreme western limit of the Lower Austral zone, but the vegetation is as a whole more nearly that of the Upper Austral. Indeed there reach us here several plants typical at this latitude of the Transition zone, such as Rhododendron, Viburnum Acerifolium (Maple-leaved Arrowwood), Aesculus octandra (Yellow Buckeye), Gaultheria (Wintergroon), Robinia (Locust), Ostrya (Hop Hornbeam), Corylus (Hazel-nut). The Rev. M. A. Curtis in his "Woody Plants of North Carolina" gives the first three as having their eastern limit in Orange County, while the other three are not recorded by him so far down as Chapel Hill.

While these Transition plants have here reached their farthest limit eastward, there are others, typical of the Lower Austral zone, which meet them at this point and go no farther westward. Such are Pinus Taeda (Old Field Pine), Quercus

lyrata (Overcup Oak), and Cornus stricta (Swamp Dogwood).

It is thus apparent that Chapel Hill is situated on the tension line between the mountains and the low country, and this fact accounts in a large measure for the wealth of its vegetation.

The plants which give the most distinguishing character to our vegetation are the Oaks, Hickories, Pines, and Poplars. The number of species of Oaks is remarkably large, (ten species and one hybrid are recorded below), and I think few other areas of equal size could show so many. The geological character of the soil does not here have a very conspicuous effect on the plant life, but some such influence can be detected in certain cases. The Hop Hornbeam for example, I have not found except on the Monroe Slates, while Vaccinium arboreum (Sparkleberry), Pieris Mariana (Stagger-bush), and Crataegus apiifolia (Parsley Haw), are much more plentiful on the Iredell Clay Loam than on other soils.

The following list of woody plants (trees, shrubs, and vines) comprises all the native and escaped species that I have so far found in a radius of two miles of Chapel Hill.* The dates following the species when present indicate the time of blooming for this season. Where dates are absent the plants had not bloomed when this list went to Press, or the time of blooming was not observed. In those genera which have representatives under two or more of the headings—Tree, Shrubs and Vines—the species are not separated, as for example in Rhus and Ilex. In the scientific names used Britton & Brown's "Flora of the Northern United States and Canada" has been followed as far as possible.

As will be seen below there are 53 trees, exclusive of introduced species, to be found at Chapel Hill. In Chapman's Southern Flora there are but 126 trees given for the whole Southern States. The total number of plants listed is 133.

* Two or three of these were found at a slightly greater distance, but they no doubt occur within these limits.

TREES.

Pinus Taeda, *L.* Old-field Pine. April 2nd.
Pinus Echinata, *Mill.* Short-leaved Pine. April 15.
Pinus Virginiana, *Mill.* Jersey Pine. About April 2.
Juniperous Virginiana, *L.* Cedar. About March 1.
Juglans Nigra, *L.* Black Walnut. Rare.
Hicoria ovata (*Mill.*) *Britton.* Shell-bark Hickory.
Hicoria alba, (*L.*) *Britton.* Mocker-nut Hickory. About April 5.
Hicoria glabra, (*Mill.*) *Britton.* Pig-nut Hickory. May 5.
Salix fragilis, *L.* Crack Willow. April 5.
Rare. Identification not absolutely certain. Only female trees found.
Salix nigra, *Marsh.* Black Willow. April 14.
Salix sericia, *Marsh.* Silky Willow. March 16.
Salix Babylonica, *L.* Weeping Willow.
Native of Asia. Occasionally escaped from cultivation.
Carpinus Caroliniana, *Wall.* Hornbeam. March 20.
Ostrya Virginiana, (*Mill.*) *Wild.* Hop Hornbeam. March 25.
Along large water courses.
Betula nigra, *L.* Red Birch. About April 5.
Along large water courses.
Fagus Americana, *Sweet.* Beech. April 31.
Castanea pumila, (*L.*) *Mill.* Chinquapin.
Quercus coccinea, *Wang.* Scarlet Oak. About April 5.
Quercus velutina, *Lam.* Black Oak. April 5.
Quercus Marylandica, *Muench.* Black-Jack Oak. April 10.
Quercus nigra, *L.* Water Oak. April 10.
Quercus Phellos, *L.* Willow Oak. March 25.
Quercus alba, *L.* White Oak. April 6.
Quercus minor, (*Marsh.*) *Sarg.* Post Oak. April 1.
Quercus digitata, (*Marsh.*) *Sudw.* Spanish Oak. April 5.
Quercus lyrata, *Walt.* Overcup Oak.
Quercus Prinus, *L.* Rock Chestnut Oak. Apr. 10.

Quercus Phellos X Quercus digitata.
Small's Oak.

This hybrid oak was first found by Mr. John K. Small near the Falls of the Yadkin River, N. C., and was described by him in the Bulletin of the Torrey Botanical Club, Vol. 22, No. 2. Feb. '95. It has not so far been reported from any other place. I have found two specimens in Chapel Hill, one, a large tree, near the cemetary, the other about fifteen feet high near the wall on the West side of the Campus. Both parents grow in the immediate neighborhood of each.

Ulmus Americana, *L.* White Elm. About March 1.
Ulmus alata, *Michx.* Wahoo Elm. About March 1.
Ulmus fulva, *Michx.* Slippery Elm. Rare.
Celtis occidentalis, *L.* Hackberry. About April 5.
Celtis occidentalis, *L. Variety pumilla, Gray.*
Shrubby Hackberry. April 17.

The tree form grows only along streams where it reaches a large size, but the variety is found on sides of hills and on rocks. One specimen of the latter, growing on almost solid rock, was found covered with bloom, though only a foot high. Note the considerable difference in time of blooming of the two forms. It is probable that the variety is entitled to specific rank.

Morus rubra, *E.* Red Mulberry. April 4.
Morus alba, *L.* White Mulberry. March 27.

Native of the Old World. Sparingly escaped. Often hurt by late frosts, and so reaching no great size.

Broussonetia papyrifere, (*L.*) *Vent.*
Paper Mulberry. April 6.

From Japan. Now commonly escaped.

Magnolia tripetala, *L.* Umbrella-tree. April 28.
Liriodendron Tulipifera, *L.* Tulip-tree "Poplar." April 3.
Sassafras Sassafras,(*L.*) *Kant.* Sassafras. March 20.
Liquidambar Styraciflua, *L.* Sweet Gum. April 1.
Platanus occidentalis, *L.* Buttonwood. April 27.
Malus Malus, (*L.*) *Britton.* Apple.

From Europe. Now common wild at the north, but rare here.

Prunus Americana, *Marsh.* Wild Red Plum. March 27.

Along medium sized streams.

Prunus Angustifolia, *Michx.* Chicsaw Plum. About Mar. 10.
Prunus serotina, *Ehrh.* Wild Black Cherry. April 18.
Amygdalus Persica, *L.* Peach.
Native of Asia. Occasionally escaped.
Cercis Canadensis, *L.* Red bud. March 16.
Gleditsia triacanthos, *L.* Honey Locust. April 30.
Robina Pseudacacia, *L.* Black Locust. April 20.
Ailanthus glandulosa, *Desf.* Tree of Heaven. May 8.
From China. Escaped, hut not so common as farther north.
Melia Azederach, L. China-Tree. May 12.
Native of Asia. Sparingly escaped.
Acer rubrum, L. Red Maple. About March 8.
Acer Saccharum, Marsh. Sugar Maple. About March 8.
Acer Negundo, L. Ash-leaved Maple. March 15.
Cornus florida, L. Flowering Dogwood. Mar. 24.
Cornus stricta, Lam. Stiff Dogwood. A Shrub.
Only along streams. This may possibly be Comus Amomum, Mill.
Nyssa sylvatica, Marsh. Black Gum. April 19.
Oxydendrum arboreum,(L.)DC Sour Wood.
Diospyros Virginiana, L. Persimmon. May 17.
Symplocos tinctoria,(L.)L'Her. Horse-sugar. April 10.
Fraxinus Americana, L. White Ash. March 23.
Chionanthus Virginica, (L.) Fringe-tree. April 15.
Paulownia tomentosa,(Thunb) Paulownia. April 17.
Baill.
From Japan. Now wild along the edges of fields.

SHRUBS.

Corylus Americana, Walt. Hazel-nut.
Alnus rugosa,(Du Roi)K.Kock. Alder. About Feb. 25.
Asimina triloba. (L.) Duval. Papaw. April 11.
Not uncommon along streams.
Asimina parviflora, Duval. April 8.
This is about as far north as this plant is known to occur. Grows in dry places.
Xanthoriza apiifolia, L'Her. Yellow-root. March 16.
Benzoin Benzoin, (L.)Coulter. Spice-bush. March 15.

Itea Virginica, L. Virginia Willow. May 18.
Hamamelis Virginiana, L. Witch-Hazel. In late autumn.
Rubus occidentalis, L. Black Raspberry. April 15.
Rubus Villosus, Ait. High Bush Blackberry. April 12.
Rubus Canadensis, L. Dewberry. April 4.
Rosa humilis, Marsh. Pasture Rose.
Amelanchier Canadensis, (L.) Medic. June-berry. March 8.
Crataegus coccinea, L. Scarlet Thorn. April 23.
Crataegus uniflora, Muench. Dwarf Thorn. April 28. Rare.
Crataegus apiifolia, (Marsh.) Michx. Parsley Haw.

Most common in low, barren places Rare in other situations.

Crataegus cordata, (Mill.)Ait. Washington Thorn. Rare.
Crataegus Crus-Galli, L. Cockspur Thorn. April 30.
Aronia nigra, (Willd)Britton. Chokeberry. March 27.
Rhus Copallina, L. Dwarf Sumac.
Rhus glabra, L. Smooth Sumac.
Rhus Radicans, L. Poison Ivy. May 8. A vine.
Rhus toxicodendron, L. Poison Oak. May 3.
Ilex opaca, Ait. American Holly. May 1.

Rare here, and not becoming large except in cultivation.

Ilex decidua, Watt. Swamp Holly. Agril 14.
Ilex Monticola, A. Gray. Large-leaved Holly. May 8.
Ilex verticillata, (L.)A. Gray. Winter-berry.
Ilex vomitoria, Ait. Yaupon. April 28.

Only one specimen found wild and it no doubt came from a tree in cultivation in one of our yards. This Ilex is a native of our coast country and does not naturslly extend so far up as Orange county.

Euonymus Americanus, L. Strawberry Bush. April 21.
Euonymus atropurpureus, Jacq. Burning Bush. About Apr. 21.

Very rare. It was not found in this State by Curtis who in his "Woody Plants of N. C." says that its occurrence had been reported to him by Elisha Mitchell. The latter probably found it near Chapel Hill as he was for a long time professor here. I have have found several specimens at Scott's Hole.

Staphylea trifolia, L. Bladder-nut. April 17.

Aesculus octandra, Marsh. March 27.

Curtis says that in Orange County this plant is but a "mere shrub, not over six feet high," but around Chapel Hill it sometimes exceeds twenty feet.

Ceanothus Americanus, L. New Jersey Tea. May 23.

Ascyrum stans, Mich. St. Peter's-wort.

Azalea nudiflora, L. Swamp Azalea. March 26.

Rhododendron Catawbiense, Mich.
Carolina Rhododendron.
April 11.

This is much farther from the mountains than this handsome shrub is reported to grow, but our plant agrees much more closely with R. Catawbiense than with R. Maxima as described by Gray, Chapman, and Britton and Brown. It seems to differ from the type only in the presence of greenish-yellow dots on the upper lobe of the corolla. This is no doubt the plant called R. Maxima by Curtis when he says that that species grows as far down as Orange County.

Kalmia Latifolia, L. Mountain Laurel. May 10.

Pieris Mariana, (L.) Benth & Hook.
Stagger-bush. May 3.

Xolisma ligustrina, (L.) Britton.
Privet Andromeda. May 20.

Leucothoe racemosa, (L.) A. Gray.
Swamp Leucothoe.

Epigaea repens, L. Trailing Arbutus. March 15.

Gaultheria procumbens, L. Wintergreen.

Gaylussacia racemosa, (Ait.) T. & G.
Black Huckleberry. April 19.

Vaccinium corymbosum, L. High-bush Huckleberry.
March 15.

Vaccinium virgatum, Ait. Black Huckleberry. March 21.

Vaccinium vacillans, Kalm. Low Blueberry. April 1.

Vaccinium stamineum, L. Squaw Huckleberry. April 5.

Vaccinium arboreum, Marsh. Sparkleberry.

Styrax grandifolia, Ait. Large-leaved Storax. April 25.

Rare and fine. Sometimes reaching a height of eighteen feet.

Sambucus Canadensis, L.	Elder. May 21.
Cephalanthus occidentalis, L.	Button-bush.
Viburnum pubescens, L.	Arrow-wood. April 17.
Viburnum acerifolium, L.	Maple-leaved Arrow-wood. May 2.
Viburnum nudum, L.	Possum Haw.
Viburnum prunifolium, L.	Black Haw. April 4.
Symphoricarpus Symphoricarpus, (L.) Mac. M.	Coral-berry.

VINES.

Clematis Virginiana, L.	Virginia Virgin's Bower.
Smilax rotundifolia, L.	Greenbrier. April 8.
Smilax Bona-nox, L.	Bristly Greenbrier. May 13.
Smilax glauca, Walt.	Glaucous-leaved Greenbrier.
Menispermumum Canadense, L.	Moonseed. May 10.
Vitis aestivalis, Michx.	Summer Grape. May 21.
Vitis rotundifolia, Michx.	Bullace Grape.
Vitis cordifolia, Michx.	Frost Grape.
Parthenocissus quinquefolia, (L.) Planch.	Virginia Creeper.
Gelsemium sempervirens, (L.) Ait. f.	Yellow Jessamine. March 22.
Bignonia crucifera, L.	Cross-vine. April 4.
Tecoma radicans, (L.) DC.	Trumpet-flower.
Lonicera sempervirens, L.	Woodbine. April 4th.
Lonicera Japonica, Thunb.	Japanese Honeysuckle. May 5.

Naturalized from Eastern Asia.

In addition to the above listed woody plants a red Raspberry and a bunch Blackberry are reported as occuring here.

NUCLEIC ACID OF THE WHEAT EMBRYO.

ISAAC F. HARRIS.*

Dr. Lauder Brunton was the first to investigate the chemical composition of cell nuclei[1]. He separated the nuclei from the red corpuscles of birds and described them as consisting of a mucin-like substance. Miescher[2], however, was the first to announce the presence of a substance of high phosphorous content which he isolated from the nuclei of pus corpuscles. This substance he termed nuclein. Later, Miescher[3] pursued his investigations to a consideration of the spermatazoa of different animals and the yolk of hen's eggs. His work was augmented by the studies of Hoppe-Seyler[4], Kossell[5], and Loew[6] on nuclein from the yeast; Plosz[7], from the liver, von Jaksch[8] and Geoghegan[9] from the brain; Lubavin[10] from cow's milk; and Worm Müller[11] from the yolk of egg.

These investigations indicated that wherever cell nuclei capable of growth and dovelopment existed, whether in the animal or vegetable kingdom, there was to be found a substance rich in phosphorous, soluble in weak alkalis, insoluble in weak acids and in artificial gastric juice. This substance they called nuclein.

All the bodies described under the name of nuclein are not identical (Hoppe-Seyler) but differ in their elementary composition. From these results we must conclude that

* A thesis presented to the Faculty of the University of North Carolina in fulfillment of a requirement for the degree of Master of Science.

1. Journal Anat. and Phys. 2nd. Series III, 91.
2. Med. Chem. Unters. V Hoppe-Seyler IV, 1872, pp 441 and 502.
3. Verhandl der nat. Ges. Basel VI, 1874, Heft I.
4. Med. Chem. Unters. IV, 500.
5. Zeit. physiol. Chem. III, IV.
6. Pfluger's Archiv., Vol. XXII, 1880.
7. Ibid. VII.
8. Ibid. VIII.
9. Physiol. Chem. I.
10. Ber. d. deutsch. Gesellsch. X, 2237.
11. Pfulger's Archiv., 1874, VIII.

"nuclein is not a chemical unit but a mixture of organic phosphorous compounds with proteid or proteid-like substances" (Worm-Müller) or more probably "that varieties of nuclein exist" (Hoppe-Seyler)[1].

Miescher[2] described his method of procedure in separating nuclein from the salmon sperm and assigned to the product the following properties: Recently precipitated, it is a colorless amorphous body, slightly soluble in water, soluble in ammonia, caustic soda and phosphate of soda. After long standing, and especially after desiccation, it becomes insoluble. Concentrated nitric acid dissolves it without color. This nitric acid solution becomes somewhat colored upon warming and brown upon the addition of ammonia. It gives neither the Millon nor the biuret reaction. Its phosphoric acid is split off gradually upon boiling with acids and alkalis.

In these substances nucleic acid was first found only in combination with proteid and this led for some time to the idea that the nucleins were phosphorized proteids. Even after Miescher separated the nucleic acid from the proteid, he continued to designate it nuclein, although he recognized its acid properties. Altmann, in 1899, was the first to distinguish sharply between nucleic acid and its protein compounds, the nucleins.

The nucleic acids have been variously investigated and the properties of those from many different sources have been delineated, but withal, our knowledge of them is still very incomplete. No one acid has been ultimately worked out and its constitution determined, though the composition of salmo-nucleic acid is best established and the decomposition products of thymo-nucleic acid are best known.

Altmann showed that nucleic acid could be split from the various nucleins and that it differed from them in having a higher proportion of phosphorous. He described his method of preparing nucleic acid by removing all the proteid possible by pepsin digestion, dissolving the insoluble residue in alkali,

1. Physiol. Chem. p 85.
2. Hoppe-Seyler Traité d'Analyse Chemique, etc., 1877, p 309.

precipitating the remaining proteid by acetic acid and separating the nucleic acid from the filtered solution by addition of hydrochloric acid and alcohol. Altmann's idea of nucleic acids was that they were organic phosphoric acids, but not such as were then known which formed compounds with proteid.

The general remarks regarding nucleic acids and the nucleins in the preceding pages may serve as a brief introduction to the one of vegetable origin which is the special subject of this paper. As we have just seen the earliest studies of the nucleins and the investigations immediately following the discoveries of Miescher were made upon products from animal sources, e. g., the blood corpuscles, pus corpuscles, glands rich in nucleated cells, etc. With the exception of the invaluable work A. Kossel and others on yeast nucleic acid, no acid of this character has been prepared from plant cells until the discovery of tritico-nucleic acid by Osborne and Campell in 1899[1]. In a study of the proteids of the wheat embryo these investigators aimed to show what proteids were predominant there and, if possible, to point out any characteristic difference between them and the constituents of the endosperm. They found that variable quantities of phosphorus in their embryo-albumin preparations caused discordant results, which discordances appeared to be in proportion to the content of phosphorus. These facts led them to examine their preparation for nucleic acid. This was found to be the cause of the former discrepancies and was later isolated in quantities sufficient for analysis and determination of some of its properties. The acid was briefly described and the investigation left in this unfinished condition until 1901. The study of tritico-nucleic acid was continued (Osborne and Harris)[1] on some preparations made from freshly prepared wheat germs secured from the Hecker-Jones-Jewell Milling Co., N. Y. The germs were received in cold weather and the extractions

1. Report Conn. Agric. Expt. Station 1899, p 305. Also Jour. Amer. Chem. Soc. 22, 379.

made as rapidly as possible. The necessity of making these extractions at a moderately low temperature and with as great expedition as possible was recognized by Miescher in his early work on salmo-nucleic acid.

PREPARATION OF THE ACID.

Kilogram portions of the germ meal were well extracted with seven times their weight of water. After agitating the mass in water for several hours the whole was transferred to large filter frames where the extract rapidly passed through cheese-cloth and was collected in large bottles. This turbid extract was saturated with sodium chloride and made distinctly acid with hydrochloric acid. This precipitated the nucleic acid in combination with protein, as large coarse flocks which hung together in a form easy to filter. This was filtered from the acid solution and washed several times with water to remove the excess of acid and salt. Each time after stirring with water the whole mass was returned to the cheese-cloth filter frame where the filtration was rapidly accomplished. The washed nuclein was suspended in 20 per cent. hydrochloric acid and subjected to pepsin digestion for several days at a temperature of about 40° C. The greater portion of the protein was thus removed. The remaining pepsin insoluble nuclein was washed, dissolved with sodium hydroxide, and to the solution was added picric acid and then acetic acid to precipitate the protein. To the clear filtrate thus produced was added 10 per cent. hydrochloric acid which caused the nucleic acid to separate in a flocculent mass which soon settled and formed a compact layer in the bottom of the containing vessel. The newly precipitated acid had the striking property of shrinking, drying and hardening under water, where in a short while it could be ground to a powder with the stirring rod. This acid was purified by dissolving in potassium hydrate and pouring into alcohol The potassium nucleate thus precipitated was dissolved in water and

1. Report Conn. Agric. Expt. Station, 1901. Also Zeit. Physiol. Chem., June, 1902.

poured into alcohol acidified with hydrochloric acid. This was repeated until such procedure left the alcohol only slightly colored from the extraction of any coloring matter from the potassium nucleate solution. This method of purification gave a product which did not yield any purple coloration when tested for the biuret reaction. This method is very efficient for purification but is accompanied with some loss of the preparation upon each solution and reprecipitation. The preparation was washed with absolute alcohol, dried over sulphuric acid and dried at 110° C. in an air bath.

ANALYSES OF THE PREPARATIONS.

Some of the purified preparations gave the following analyses.

TRITICO-NUCLEIC ACID.

	A.		B.		C.	
	P. C.	At. Ratio	P. C.	At. Ratio	P. C.	At. Ratio
C.	32.73	44.68	35.41	41.84	34.65	40.76
H.	4.32	70.76	4.37	62.00	4.30	60.72
N.	15.55	18.16	16.07	16.28	15.88	16.00
P.	7.57	4.00	8.75	4.00	8.70	4.00
K.	2.86	1.20	.32		1.42	
O.	36.97	37.84	35.08	31.00	35.05	30.92
	100.00		100.00		100.00	
Ash.	12.95		3.52		13.71	
PO_3	10.09		3.20		12.29	
K.	2.86		.32		1.42	

ASH-FREE ACID.

$C_{15}H_{72}N_{18}P_4O_{38}$ $C_{42}H_{62}N_{16}P_4O_{31}$ $C_{41}H_{61}N_{16}P_4O_{31}$

The discrepancies in the analyses above are due largely to the fact that all the preparations contained some contaminating inorganic base. The polybasic nature of this acid causes the formation of acid sodium or potassium salts which are insoluble in water and hence, when the attempt is made to separate the free acid from its alkaline solution the corresponding acid salt is thrown down, from which it has been impossible to remove the foreign base. If the atomic ratio is

calculated from the above analyses more concordant results are obtained. In the more carefully purified preparations the ratio of phosphorus to nitrogen is approximately 4 : 16, but in the less pure ones a ratio as high as 4 : 18 has been obtained. The experiments indicated that it is probably as hard to remove organic as inorganic bases and hence we may assume that there is usually an excess of nitrogen present. Preparations B and C were most extensively purified of any and doubtless their analyses must closely represent the true composition of this acid. Of these two purest preparations it is noticeable that in the case of B the ratio of phosphorus to nitrogen is 4 : 16¼, while in that of C the ratio is 4 : 16. It is also true that in the former case (that of B) we find the ratio of phosphorus to carbon 4 : 42, while in the latter it is 4 : 41. Representing it thus,

	P : N	P : C
Preparation B.	4 : 16¼	4 : 42
Preparation C.	4 : 16	4 : 41

we confirm our results with analyses of other preparations where an increase of carbon was found with that of nitrogen. This indicates that preparation C is nearer free from contaminating nitrogen and carbon than B, and leads us to think that it more exactly represents the composition of the acid, and hence the ratio of the phosphorus to carbon is 4 : 41 and not 4 : 42. This gives preference to a formula, $C_{41}H_{61}N_{16}P_4O_{31}$, for this nucleic acid.

PROPERTIES OF THE ACID.

The purified product was an amorphous, nearly white mass, readily soluble in dilute alkalis and had a characteristic acid reaction. The solubility of this tritico-nucleic acid is difficult to determine, since all the preparations have contained some inorganic base. Those preparations nearest free from base formed a pasty, sticky mass with cold water which would not dissolve when boiled for some time. Only one preparation which had about 3 per cent. of base did dissolve when heated

with water and when in solution gave a decided acid reaction to litmus.

SPLITTING PRODUCTS OF THE ACID.

PURIN NITROGEN: Upon hydrolysis with 2 per cent. sulphuric acid for thirty minutes, it was found that guanin, adenin and some phosphoric acid were split off from the original molecule. In order to determine definitely the proportion of purin bases in the acid, quantitative estimations of guanin and adenin were made as follows: One gram portions of different preparations were boiled for 30 minutes each with 25 cc. of 2 per cent. sulphuric acid. The clear solution was somewhat diluted, made ammoniacal and allowed to stand for 12 hours. The precipitated guanin was filtered off, washed free from ammonia and nitrogen estimated in it by the Kjeldahl method. To the filtrate containing the adenin was added silver oxide ammonia which caused the adenin silver to separate in a jelly-like form. This was likewise washed ammonia-free and nitrogen determined in it. The results of several of these estimations were as follows:

Determinations made on *one gram* Nucleic Acid

	Found			Calcu. for
	A	B	C	1 Mol.
Grams Guanin N	.0579	.0573	.0548	.0500
Grams Adenin N	.0494	.0447	.0433	.0500
	.1073	.1020	.0981	.1000

These figures correspond to

				Calcu. for
	A	B	C	1 Mol.
Grams Guanin	.1247	.1235	.1182	.1080
Grams Adenin	.0953	.0865	.0835	.0964
	.2200	.2100	.2017	.2044

The purest of the preparations thus treated showed a little more of the purin bases than would indicate a ratio of one molecule of guanin and one of adenin to four of phosphorus. The probable retention of some adenin in the guanin precipitate accounts for the tendency toward high results in deter-

minations of guanin and low ones in the case of adenin in the examples given above.

PYRIMIDIN COMPOUNDS: Twenty grams of tritico-nucleic acid were dissolved in 45 cc. of 20 per cent. sulphuric acid and heated in an autoclave to a temperature of 150° to 160° for two hours. This treatment gave an insoluble black mass which formed a considerable part of the whole and was separated from the solution by filtration and washing. The filtrate and washings were made to contain 5 per cent. sulphuric acid and precipitated with phospho-tungstic acid. The bulky phospho-tungstic acid precipitate of the purin bases was filtered off and well washed. To the filtrate and washings was added a slight excess of barium hydrate more than enough to completely separate the phospho-tungstic acid. The excess of baryta in the filtrate was removed with a slight excess of sulphuric acid. To this solution, freed from barium sulphate, was added silver nitrate and ammonia until the solution was neutral to litmus. This produced a voluminous white precipitate. This silver precipitate was decomposed with hydrogen sulphide and the solution evaporated to dryness. This dry mass weighed 1.78 grams which constituted about 11 per cent. of the entire acid. This residue was dissolved in a small volume of hot water and the solution allowed to cool slowly, whereupon a large mass of colorless crystals separated in microscopic needles. Upon this crystalized substance a melting point was successfully obtained in melted parrafin. This was found to be 337° (uncorrected) which agrees closely with that obtained for uracyl by Emil Fischer who found this to be 336°. This was identified as uracyl beyond all doubt, as the following analysis shows.

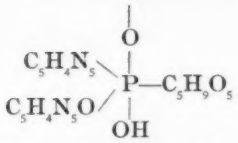
	Found	Found	Calcu. for $C_4H_4N_2O_2$
Carbon	43.08	43.21	42.86
Hydrogen		3.65	3.57
Nitrogen		25.09	25.05

This determination points to the fact that there are two molecules of uracyl in this nucleic acid. Eight per cent.

uracyl would correspond to one molecule, but as 11 per cent. was found we must conclude that at least two molecules are present and the shortage of 5 per cent. was caused by the long and tedious method of separation, involving bulky precipitates and concentrated solutions.

Carbohydrate Constituents: There is a carbohydrate component of tritico-nucleic acid whose presence and extent was determined in the following manner: By direct test for copper reduction we find no indication of a reducing sugar, even upon prolonged boiling with hydrochloric acid. The distillate collected from prolonged boiling with acids, however, is found to contain furfurol which is also a characteristic of the yeast nucleic acid. One gram portions of the wheat acid were boiled with hydrochloric acid sp. gr. 1.06 and the distillates fractionally collected and precipitated with phloroglucin according to the method adopted by the Official Agricultural Chemists. The precipitated furfurol phloroglucid was collected on Gooch crucibles, dried and weighed. These results gave an average slightly above 32.0 per cent. when figured as pentose. This is found to correspond to three molecules of pentose in this acid, since by the formula obtained 10.87 per cent. is required for one molecule of this group.

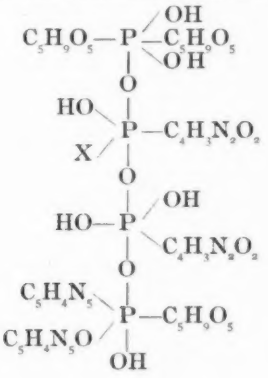
Phosphorus of the Acid: We have no final proof of the binding of the phosphorus or its position in the molecule of tritico-nucleic acid. Phosphoric acid is split off upon boiling with either acids or alkalies. It is noticeable, however, that nearly one-fourth the phosphoric acid is readily split off from the molecule and the other three-fourths is broken up and changed into ortho-phosphoric acid more slowly. This seems to indicate a different binding and position in the molecule for one phosphorus atom from the other three. Since about 25 per cent. of the phosphorus is thus readily split off and at the same time the purin bases set free, we may with some good reason suggest that very probable one of the atoms of phosphorus is in combination with one molecule of guanin, one of adenin and one of pentose. If this reasoning be well founded we would expect such an arrangement in the molecule as this:



REMAINING UNDETERMINED COMPONENT: There is a shortage in the list of identified decomposition products which aggregates about 10—15 per cent. of the acid. We have little definite information regarding this body to offer further than its approximate amount and its property of precipitating with phospho-tungstic acid from the acid solution of the decomposition products. From this phospho-tungstic acid precipitate we have not as yet been able to isolate it in more than small quantity which was accomplished by shaking the precipitate with ether according to Winterstein's method.[1] This small amount gave a precipitate with picric acid and also with silver nitrate, but the latter was so contaminated with silver phosphate that no definite statements of value can be made in regard to its nature.

POSSIBLE STRUCTURAL FORMULA.

With the work on this subject in this unfinished condition it would be impossible to assign to the acid a definite molecular arrangement with any degree of certainty, but we would suggest with good reason the possible arrangement as shown below:



1. Zeit. physiol. Chemie 34, 153, 1901.

It has been shown in the foregoing pages that for every four atoms of phosphorus there are one of guanin, one of adenin and two of uracyl. These account for fourteen of the sixteen atoms of nitrogen found in the acid. It is very probable that the two remaining nitrogen atoms belong to the unknown constituent which has shown itself to be a basic substance. Based upon the furfurol estimation we have calculated three pentose groups for every four phosphorus atoms. And a silver salt of the acid has been prepared which contained six atoms of silver, indicating six hydroxyls for every four atoms of phosphorus. These groups are arranged arbitrarily with the exception of the guanin, adenin and one pentose group attached to one phosphorus atom which has been shown to have a different position from the others in the molecule. In the formula we have assumed penta-valent phosphorus although the $P(OH)_5$ group is unknown in the free state. According to Stokes,[1] however, the esters of pentahydroxyl phosphoric acid are stable bodies.

This work was carried out under the supervision of Dr Thomas B. Osborne of the Connecticut Agricultural Experiment Station, and to him I wish to express my sincere thanks for his kindly aid and sympathy.

1. Amer. Chem. Jour. 16, 123, 1894.

MERCUROUS SULPHIDE.

CHAS. BASKERVILLE.

In a paper "On the Reactions between Mercury and Concentrated Sulphuric Acid"[1] by Mr. F. W. Miller and the writer, two statements were made, which, while true for the conditions given, require modification in the light of knowledge recently gained:—"The reaction is by no means like that of copper"[2] (p. 874) and "No sulphide was produced, nor any free sulphur" (p. 876). By great variation of one of the factors, time, sulphide was obtained. The experiment was continued through a period of five years and one week. Ten grams of pure mercury (l.c.) were covered with fifty grams of chemically pure sulphuric acid (99.65 per cent) in a well ground glass stoppered bottle of about 100 c.c. capacity and allowed to remain at the temperature of the laboratory (never over 30°C.) for the period mentioned. While the bottle was never subjected to the direct rays of the sun, no attempt was made to shield it from the light.

When the bottle was opened there was a strong outward pressure and noticeable quantities of sulphur dioxide escaped. This corroborates the statements put forward in our second paper[3] in controversion of the criticism of Pitman.[4] Morley (1. c.) and Berthelot[5] have independently also shown that mercury and sulphuric acid of maximum concentration react at ordinary temperatures with the evolution of sulphur dioxide.

The point of especial interest in the experiment lay in the simultaneous formation of a sulphide of mercury, which showed that the mercury resembles copper in this reaction more than was thought. Upon the bright metal there separated

1. Journ. Am. Chem. Soc., XIX, Nov. 1897.
2. Journ. Am. Chem. Soc., XVII, Nov. 1895 and XVIII, Nov. 1896.
3. Journ. Am. Chem. Soc., XX, 515.
4. Journ. Am. Chem. Soc., XX, 100.
5. Chem. News, 76, 325; Compt. rend. 125, 20.

flakes which resembled plates of *Mercurous Sulphide*. The acid was decanted, a large volume of water added and quickly decanted. This was done several times. The bottle was inclined and revolved so that most of the sulphide was caused to cling to the sides of the vessel, the metallic mercury poured out and the sulphide thrown upon a filter, washed with alcohol (95 per cent) until the wash water was no longer acid. The brownish black plates (about 0.2 gram) were dried at 110° C. and analized by Mr. R. O. E. Davis of this laboratory:—

AMOUNT TAKEN.	SULPHUR FOUND PER CENT.	MERCURY FOUND PER CENT.	CALCULATED FOR Hh_2S.
0.0866	8.23	——	7.41
0.0707	——	91.94	92.59
Total,		100.17	100.00

The quantity remaining was too small to examine for the presence of free sulphur, although from the analysis it appears that 0.82 per cent of free sulphur was present. As no quantitative determination of the sulphnr dioxide, mercury sulphates produced, and so forth, were made, it is impossible to state the formulas.

Authoritative works(Richter, Dammer, etc.) state that mercurous sulphike is not definitely known. Berzelius[1] said the black precipitate produced by H_2S with mercurous salts was Hg_2S, but Barfoed[2] has shown that it is a mixture of HgS and Hg. Antony and Sestini[3] state that hydrogen monosulphide acting upon mercurous salts below 0° C. give Hg_2S, which above that temperature decomposes into HgS and Hg.

Mercurous sulphide heated in a closed tube turns white (doubtless due to oxidation) becomes slightly yellow, then melts to a dark orange brown liquid, which changes to a white solid solid on cooling, as does mercurous sulphate.

University of North Carolina.

1. Archiv. d. Apothekervereins im nordl Deutschland, von Brandes, 18, 292.
2. Journ. fur prakt. Chem. 93, 230.
3. Gazetta chimica italiana 24, I, 193.

CERTAIN DERIVATIVES OF TRICHLORETHYLIDENE-DI-P-NITROPHENAMINE.

ALVIN S. WHEELER AND M. R. GLENN.

The preparation of trichlorethylidene-di-p-nitrophenamine is described by Eibner[1] and also by Wheeler and Weller[2]. It is a condensation product of chloral and paranitraniline. The reaction is a very smooth one, an almost quantitative yield being obtained. The reaction is as follows:

$$CCl_3CHO + 2\,C_6H_4NO_2NH_2 = CCl_3CH(C_6H_4NO_2NH)_2 + 2\,H_2O.$$

It is a yellow crystalline powder, melts with decomposition at 216° and is insoluble in most organic solvents. In fact it is the most insoluble of all the diphene compounds known at present.

Reduction. Many attempts were made to reduce the nitro groups but most reducing agents had no action whatever upon the substance. However a reaction readily took place in glacial acetic acid in the presence of zinc dust, even at 0°. A brown powder was obtained as the crude product. Much water was added to this, the liquid was filtered and the filtrate was saturated with hydrogen sulphide. The zinc sulphide was filtered off, the filtrate neutralized exactly, concentrated considerably on the water bath, cooled, made alkaline and extracted with ether. On distilling off the ether, a crystalline residue was obtained which rapidly turned violet on exposure to the light. It decomposed about 260° and to our surprise an analysis for chlorine showed so small an amount present that it could only be an impurity. It is quite possible that the nitro groups cannot be reduced without otherwise affecting the molecule.

Action of Alcoholic Potash. Dichlorhydroxylethylidene di-p-nitrophenamine, $CCl_2OH.CH(C_6H_4NO_2NH)_2$. In the reduction work it was observed that alcoholic potash caused the yellow trichlor compound to assume instantly a brilliant red color. After many trials to discover the best conditions for

the reaction, the following method was adopted. Ten grams of potassium hydroxide were dissolved in sixty grams of absolute alcohol, cooled and then ten grams of the trichlor body were added. The mixture was heated on the steam bath several times a short while each time until only a gritty substance, potassium chloride, remained. At each heating the solution became deeper red. No noticeable amount of gas was evolved but when care was not exercised in heating considerable decomposition would take place, indicated by an abundant evolution of gas. When the reaction was complete, the solution was cooled and poured into 200 cubic centimeters of ice water. A heavy yellowish brown precipitate came down which was quickly filtered off. The precipitate, after drying upon a clay plate, weighed 6.3 grams. The theoretical yield for a dichlor monohydroxyl compound is 95 per cent or 9.5 grams. The yield of the crude product is therefore 66 per cent of the theoretical. The substance was recrystallized four times by dissolving in hot chloroform and precipitating with ligroin. This raised the melting point to 173°—174°. It was finally recrystallized five times from absolute alcohol, the melting point rising to 177°—178° (uncorr.). After keeping seventeen days in a dessicator its weigh became constant.

The fusion method for the determination of chlorine gave high results, over one per cent too high. The Carius method however gave satisfactory results. For nitrogen the Dumas method was used.

I. 0.2178 gram of substance, M. P. 177°–178°, gave 0.1613 gram of AgCl.

II. 0.1559 gram of substance gave 0.1170 gram of AgCl.

III. 0.1872 gram of substance 24.4 cc. of nitrogen at 22.5° and 745 mm.

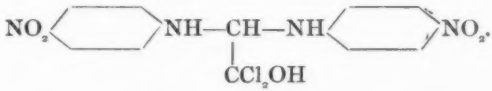
	CALCULATED FOR $CCl_2OH.CH(C_6H_4NHNO_2)_2$	FOUND I.	II.	III.
Cl	18.31	18.31	18.55	
N	14.50			14.42

The reaction therefore is represented by the following equation:

$$CCl_3CH(C_6H_4NO_2NH)_2 + KOH = CCl_2OHCH(C_6H_4NO_2NH)_2 + KCl.$$

The dichlorhydroxyethylidene di-p-nitrophenamine is a yellow body, crystallizing from methyl or ethyl alcohol in brilliant prismatic crystals, which easily turn brown on exposure to the sunlight. This compound is also soluble in boiling water, ether, hot cloroform, hot benzol and cold acetone. It is difficultly soluble in cold absolute alcohol and requires 75 parts of boiling alcohol.

Its graphic formula is:



Action of Sodium Methylate. Dichlormethoxyethylidene di-p-nitrophenamine, $CCl_2OCH_3CH(C_6H_4NO_2NH)_2$. The hydroxyl group having been substituted in the molecule, the next attempt was to introduce the methoxy group. Five grams of metallic sodium were dissolved in 100 cubic centimeters of absolute alcohol, cooled and then five grams of the trichlor compound were added. A brilliant red color was instantly produced. The mixture was very carefully heated on the steam bath until only a gritty residue of sodium chloride remained. On cooling it became a reddish-black jelly like mass, but the addition of 25 cc of alcohol converted it again into the liquid condition. The deep red liquid was then poured into 300 cc. ice water. A heavy dark brown precipitate was formed which was quickly filtered off. After drying upon a clay plate it weighed 4.5 grams and melted between 140°-150°. It was recrystallized seven times from absolute alcohol, the melting point being raised to 176°-177° and the weight falling to 2.25 grams. The theoretical yield should be 99 per cent. or 4.95 grams. The actual yield of the pure body then

was 45 per cent. of the theoretical. After nine days in dessicator the weight became constant. A determination of chlorine by the Carius method gave the following result:

0.1828 gram of substance gave 0.1334 gram of silver chlorid.

	CALCULATED FOR $CCl_2OCH_3CH(C_6H_4NO_2NH)_2$	FOUND
Cl	17.67	18.00

The dichlormethoxyethylidene di-p-nitrophenamine is a light yellow crystalline body, easily becoming opaque on exposure to the sunlight. It crystallizes from alcchol in rectangular transparent plates. It is soluble in cold chloroform, ether and acetone, less soluble in cold methyl and ethyl alcohol. The solubility is much increased by heat.

Action of Bromine. If one molecule of the trichlor body is added to two molecules of bromine dissolved in glacial acetic acid and the mixture warmed on the steam bath, a separation of beautiful iridescent needles takes place while the solution is still hot. After cooling they are filtered off and recrystallized first from benzol in which any unchanged trichlor body will not dissolve and then from glacial acetic acid. The melting point was 202°-203°. A number of bromine determinations were made, but low results were always obtained. Either the compound was not fully decomposed or the bromine which was used contained sufficient chlorine to make a mixture of bodies.

University of North Carolina.
Organic Laboratory.

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